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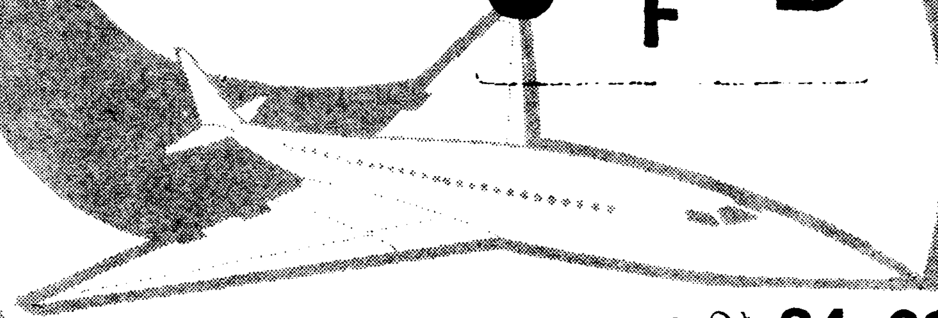
National Airspace System Exploratory Assessement for Year 2005

Douglas Baart



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NOTICE

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Please insert the following two pages to the enclosed document, as follows:

Cover - remove original cover and replace

Addendum - insert after Table of Contents

Addendum to DOT/FAA/CT-TN 94/5

The exploratory assessment of the National Airspace System for the year 2005 produced the following delay figures.

System-Wide Airborne and Ground Delay in hours

Airborne Delay		Ground Delay	
Departure Fix	15690	Airport Arrival	850350
Arrival Fix	37070	Airport Departure	734890
Restriction	54490		
Sector	328850		
Total	436100	Total	1585240

Ground delay represents 78 percent of the total delay for the year 2005. Airport arrival delay is the amount of time that a flight is delayed because the landing runway is occupied. The service time of an arrival is based on airport engineering specifications of departure and arrival capacities, and departure and arrival queue lengths. Airport departure delay is composed of pushback delay from a gate, and taxi delay to and from an active runway.

Airborne delay consists of departure and arrival fix delay, restriction, and sector delay. Minimum service times at arrival and departure fixes are used to sequence flights to and from terminal airspace. Delay is accumulated if the demand of an arrival or departure fix exceeds the capacity to meet it. Sectors and restrictions are also used as a means of spacing flights as they compete for airspace.

Validity Issues

Simulation results from the 1990 baseline scenario were compared to statistics accumulated from 1993 Air Transport Association (ATA) findings from 1990. The following table compares percent of delay by phase of flight.

	Airborne	Gatehold	Taxi-out	Taxi-in	% excess 15 min
ATA	29 %	6.8 %	48 %	16 %	10.3
NASPAC	22 %	9.0 %	52 %	17 %	12.1

The following table illustrates the delay cost comparisons in millions of dollars for the year 1990.

	Airborne	Ground	Passenger	Totals
ATA	576	800	1000	3301
NASPAC	510	1100	1300	3921

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16. Abstract

This report documents the exploratory assessment of the National Airspace System (NAS) for the year 2005. The National Airspace System Performance Analysis Capability (NASPAC) Simulation Modeling System (SMS) was used to simulate the future air traffic control (ATC) system. Airport improvements expected to be completed by the year 2005 were based on the National Plan of Integrated Airport Systems (NPIAS) and future air traffic demand was based on the 1991 Terminal Area Forecast (TAF). Results of the analysis showed an increase in system-wide delay of 4.3 minutes-per-aircraft over 1990 levels, resulting in 13.2 billion 1992 dollars in total delay cost for the year 2005. The analysis showed that airfield capacity limitations are the major cause of delay that is projected for the future ATC system. Airports which we anticipate to have the largest increase in delay over current levels are located in southern California and southern Florida. The results suggest that more emphasis should be placed on acquisition investments that alleviate airfield congestion.

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EXECUTIVE SUMMARY

INTRODUCTION

The objective of this study is to understand the future needs of the National Airspace System (NAS). Throughput and delay at major airports were analyzed for the year 2005. Future system improvements designed to increase airport and airspace capacity were used.

This report explores future system needs by simulating capacity-related improvements to the National Airspace System (NAS). It identifies congested airspace and airports based on projected improvements to the NAS. Throughput and delay were used to measure the performance of the future Air Traffic Control (ATC) system.

RESULTS

Over 5.1 million hours (h) for passenger delay and 2.9 million h for operational delay were recorded for the year 2005. This accounts for an average of 10.1 minutes of delay-per-aircraft in the NAS.

Delay cost amounts to 8.5 billion dollars for passenger delay and 4.7 billion dollars for operational delay for the year 2005.

System-wide delay savings for technological advances are 134,000 h for independent parallel approaches, 31,000 h for dependent parallel approaches, 345,000 h for nonparallel approaches, and 75,000 h for improved longitudinal approaches.

Less than 35 percent of the total delay was attributed to adverse weather for the year 2005.

Total system-wide delay for the year 2005 amounted to 5.1 million hours (h) for passenger delay and 2.9 million h for operational delay. This accounts for 8.5 billion and 4.7 billion dollars in delay costs respectively. Operational delay refers to delay that accumulates during the course of a flight due to capacity limitations of ATC resources. Passenger delay is the difference between the scheduled arrival time and simulated arrival time of a flight at an airport. System-wide delay averages 10.1 minutes-per-aircraft for the future system compared to 1990 levels of 5.8 minutes-per-aircraft.

As expected, those airports that have no planned improvements to increase capacity show the largest annual delay. These airports include San Francisco International Airport (SFO), 179,000 hours (h); Los Angeles International Airport (LAX), 156,000 h; Miami International Airport (MIA), 149,000 h, John Wayne Airport-Orange County Airport (SNA), 117,000 h; Minneapolis-St. Paul International Airport (MSP), 94,000 h; and Fort Lauderdale/Hollywood International Airport (FLL), 90,000 h.

Ground delay made up 78 percent of the total delay for the future system. The delay caused by adverse weather is composed of 60 percent ground delay and 40 percent airborne delay.

Anticipated future technological advances can result in significant savings in system-wide delay. For example, savings number 135,000 h for independent parallel approaches, 31,000 h for dependent parallel approaches, 345,000 h for nonparallel approaches, and 75,000 h for improved longitudinal approaches.

The analysis also showed that delay attributed to adverse weather makes up 35 percent of the total delay for the year 2005. It was also noted that ground delay contributed to 78 percent of the total delay and weather-related delay is composed of 60 percent ground delay and 40 percent airborne delay.

CONCLUSION

Airfield capacity limitations caused most of the future system delay. Over three-fourths of all delay comes from ground operations and one-third of all delay is related to adverse weather.

The analysis suggests that the majority of the future ATC system delay is caused by airfield capacity limitations. The analysis revealed that over three-fourths of the delay recorded in the model comes from ground operations versus air; and, one-third of all the future system delay is caused by adverse weather. This would indicate that the future ATC system would not adequately accommodate the projected increase in traffic volume at major airports in the NAS without substantial delay.

Future studies will include an improved set of data to reflect advances in technologies designed to increase system capacity.

As an exploratory assessment, this study does not include all of the technological improvements that might exist in the future ATC system. Future studies of NAS performance will include an improved baseline which reflects new technologies designed to increase system capacity.

SYSTEM PERFORMANCE EVALUATION

INTRODUCTION.

A major effort from the Federal Aviation Administration (FAA) Research, Engineering and Development (RE&D) Office is underway to safely increase air traffic control (ATC) system capacity. Current forecasts project serious delay in the absence of airport and airspace improvements designed to increase system capacity. The National Airspace System Performance Analysis Capability (NASPAC) Simulation Modeling System (SMS) was used to study the impact new airport runway configurations, advanced technologies, and revised ATC procedures have on system performance. NASPAC SMS was designed to provide system-wide assessment of any changes to the ATC system in terms of throughput and delay. Evaluations of the National Airspace System (NAS) are based on future traffic growth and projected airport and airspace capacity parameters. It is a macro model that traces individual aircraft through the NAS and records the rippling effect of delay as it propagates throughout the system. We used the model as a strategic system planning tool by providing a quantitative assessment of the future ATC system based on projected growth, advances in future technology, and planned airport improvements.

METHODOLOGY.

A baseline scenario was used to simulate traffic flows, as they are projected to exist in the year 2005, with all of the airport improvements in place. A 1990 baseline scenario was also developed so that comparisons could be made with current operations in the NAS. The year 1990 was used because annualization techniques were developed from historical data observed in that year. Airport capacity estimates that were used in the 2005 baseline scenario were based on airfield improvements that were outlined in the National Plan of Integrated Airport Systems (NPIAS). Three runs of the model were averaged for each scenario to account for statistical variations associated with one run.

In review of the proposed expenditures contained in the NPIAS, 26 NASPAC airports were identified to receive funding for either new runways or major runway extensions. Funding for these airport enhancements are derived from local, state, and federal agencies with the intent of accommodating traffic increases projected to the year 2005 by the Terminal Area Forecast (TAF). The 1990 and 2005 baseline includes 6 days that reflect different weather conditions in the NAS, allowing annualization of findings.

The MITRE Corporation developed a method for computing the estimated annual results of the NASPAC-based analysis. Six scenario days were selected as representative of varying levels of Instrument Meteorological Conditions (IMC) and Visual Meteorological Conditions (VMC) across the 58 NASPAC airports. To compute the annual results, weighting factors for each scenario day were applied according to the frequency of

occurrence of similar days in a year. Table 1 shows the weights applied to the 6 scenario days.

TABLE 1. WEIGHTING FACTORS FOR THE SIX WEATHER SCENARIOS

Percent(%) VMC	Scenario Day Chosen	Weighting Factor (No. Days/Yr.)
95% - 100%	January 13, 1990	80.00
90% - 95%	September 27, 1990	127.50
85% - 90%	May 16, 1990	86.25
80% - 85%	March 10, 1990	23.75
70% - 80%	March 31, 1990	17.50
< 70%	December 22, 1990	30.00

Programs that address technological advances, designed to increase system capacity, were studied. These programs are designed to reduce separation standards in the en route and terminal environment. They include advanced surveillance and communication technologies, advances in terminal and en route automation technology, wake vortex advisory and detection devices, and technology that will reduce aircraft separation for Instrument Flight Rules (IFR) independent parallel approaches. They are designed to optimize the use of runways under IMC. The Aviation System Capacity Plan lists potential airports that would benefit from these advances through approach procedure changes. Scenarios that were developed to increase airport capacity include: independent parallel IFR approaches, dependent parallel IFR approaches, non-parallel IFR approaches, and improved IFR longitudinal separation.

In order to evaluate the effects that adverse weather has on delay, a scenario was developed to remove IMC from all of the modeled airports. This was accomplished by using all of the VMC airport capacity estimates through the simulation. While VMC is unlikely to occur at all of the modeled airports, for the entire day, it was used for the scenario so that the affects adverse weather has on delay could be identified. Comparisons were made between the 2005 baseline, with and without IMC weather, for the entire year.

As a means of determining where the majority of the delay was occurring, ground and airborne delays were summarized and presented on a system level, and for individual airports. Ground delay consisted of pushback delay at a gate, and taxi delay to an active runway. Airborne delay results from airspace capacity limitations, such as the delay a flight might experience at an arrival fix, departure fix, or sector.

NASPAC OVERVIEW.

The NASPAC SMS is a discrete, event-simulation model that tracks aircraft as they progress through the NAS, and compete for ATC resources. Resources in the model include airports, sectors, flow control restrictions, and arrival and departure fixes. NASPAC evaluates system performance based on the demand placed on resources modeled in the NAS, and records statistics at 50 of the nation's busiest airports, and 8 associated airports. NASPAC simulates system-wide performance, and provides a quantitative basis for decision making related to system improvements and management. The model supports strategic planning by identifying air traffic flow congestion problems, and examining solutions.

NASPAC analyzes the interactions among many components of the airspace system, and the system's reaction to projected demand and capacity changes. The model was designed to study nationwide system performance rather than localized airport changes in detail, therefore, airports are modeled at an aggregate level. The model shows how improvements to a single airport can produce effects of delay that ripple through the NAS. Each aircraft itinerary consist of several flight legs during the course of a day. If an aircraft is late on any of its flight legs, successive flight legs may be affected. This is the way delay accumulates in the model.

NASPAC records two different types of delay, passenger and operational. Passenger delay is the difference between the scheduled arrival times contained in the Official Airline Guide (OAG) and the actual arrival times, as simulated by NASPAC. Operational delay is the amount of time that an aircraft spends waiting to use an ATC system resource.

Traffic profiles consist of scheduled and unscheduled demand for each modeled airport. Scheduled demand is derived from the OAG and is used as the baseline from which future growth is projected. Unscheduled demand is determined from daily and hourly distributions taken from real world data (tower count). The TAF data were used to estimate future growth.

Key output metrics recorded in the model include delays and throughput at airports, departure fixes, arrival fixes, restrictions, and sectors, system-wide and at all modeled airports. Operational delay consists of airborne and ground delay. Airborne operational delay is the delay that a flight experiences from takeoff through navigational aids, sectors, and static and dynamic flow control restrictions, and is assigned to the flight-arrival airports. Ground operational delay accumulates when an aircraft is ready to depart but has to wait for a runway to taxi on or takeoff from. Sector entry delay occurs when the instantaneous aircraft count or hourly aircraft count parameters for that sector are exceeded. Monetary assessments are derived by translating delay into measures of cost to the user by using the Cost of Delay Module which was incorporated into version 3.1 of the NASPAC SMS.

The Cost of Delay Module was developed by the FAA Technical Center to be incorporated into the NASPAC SMS. This module addresses the savings that would be realized when changes are made to the ATC System. It translates delay into a cost metric to provide a better understanding of potential cost saving measures.

The Cost of Delay Module uses the latest data acquired from the Economic Analysis Branch (APO-220) as a means of determining operational and passenger costs. These costs include crew salaries, maintenance, fuel, equipment, depreciation, and amortization, and are reported by the airlines on a quarterly basis, on Form 41, to the Department of Transportation. The data are aggregated by airlines and aircraft types, and used as a reference for the Cost of Delay Module. This information is divided into airborne and ground costs for each airline and aircraft type in which cost information is reported. Passenger cost estimates were derived by using an FAA-endorsed constant of $40.50, provided by the Office of Aviation Statistics, multiplied by the hourly delay absorbed by all of the passengers aboard the flight. The estimated number of passengers aboard each flight depends on aircraft type.

ASSUMPTIONS AND CAVEATS.

All of the airport capacity estimates used in the analysis, for the year 2005, were based solely on airport improvements projected in the NPIAS. The 1991 TAFs were used to project future traffic growth. These forecasts depend on many factors which are subject to change, such as economic, technological, etc. The annualization method used in the 2005 scenario is an approximation, and is based on weather observations taken from the year 1990. The model does not include re-routing or other methods used to minimize the impacts of adverse weather.

Table 2 displays all airport improvement projects expected to be completed by the year 2005. See appendix A for airport abbreviations.

Four scenarios, developed to simulate advances in technology designed to increase runway capacity for the year 2005, include: independent parallel IFR approaches, dependent parallel IFR approaches, non-parallel IFR approaches, and improved longitudinal separation. These scenarios were assumed to include all of the airport improvements mentioned, and were evaluated independent of each other. Airport arrival rate increases defined for each of the four scenarios were obtained from the Aviation System Capacity Report. System level results were quantified for each of the scenarios.

TABLE 2. AIRPORT IMPROVEMENTS MODELED

Airport	Type of Improvement	Specifics
ATL	New runway	3,000 ft south (5th parallel).
BWI	New runway	10R/28L.
CLT	New runway	18W/36W, assume independent IFR.
CVG	New runway	18/36, assume independent IFR.
DEN	New Denver	airport. (DVX)
DFW	Two new runways	GA rwy 16/34, rwy 18/36.
DTW	Two new runways	9R/27L and 4/22.
FLL	Runway extension	9R/27L.
IAD	Two new runways	1W/19W and 12R/30L.
IAH	New runway	8L/26R.
MCI	Two new runways	1R/19L and 9R/27L.
MCO	New runway	17L/35R.
MEM	New runway	18L/36R.
MKE	Runway extensions	1L/19R and 7L/25R.
MSY	New runway	1L/19R.
ORD	Relocate runways	4L/22R and 9L/27R.
	Runway extensions	14L and 22L.
	Two new runways	14/32 (3rd parallel).
		9R/27L (3rd parallel).
PHL	Relocate runway	9L/27R.
	New runway	8/26.
PHX	New runway	8S/26S (3rd parallel).
PIT	New runway	parallel, assume independent IFR.
RDU	New runway	5/23. Assume independent IFR.
SDF	Two new runways	17L/35R and 17R/35L (parallels).
SJC	Runway extension	12L/30R for air carrier operation.
SLC	New runway	16W/34W.
STL	New runway	12L/30R, 4,300ft from parallel.
SYR	New parallel runway	10L/28R.
TPA	New parallel runway	18/36.

INDEPENDENT PARALLEL IFR APPROACHES. Changing current separation standards between parallel runways, from 4300 feet (ft) to 3000 ft, through the use of quick scan radar technology, would allow an increase in the average number of arrivals at an airport. An increase of 12 to 17 arrivals may be realized by eliminating diagonal separation for dependent parallel arrivals, and using two independent arrival streams. Airport arrival rates were modified to reflect this new technology under IFR. These airports include: ATL, BWI, CLT, CVG, FLL, JFK, LGB, MCI, MEM, MSP, MSY, PDX, PHL, PHX, RDU, SFD, SLC, SYR.

DEPENDENT PARALLEL IFR APPROACHES. This scenario reflects the reduction of diagonal separation, from 2 nautical miles (nmi) to 1.5 nmi, between aircraft arriving on parallel runways separated by less than 2500 ft. Advances in wake vortex technology may permit this reduction, yielding an additional average of four arrivals-per-hour. Airports that could take advantage of this technology include: ATL, BNA, BOS, CLT, CVG, DEN, DTW, LGB, MCO, MKE, OAK, PHL, PIT, STL.

NON-PARALLEL IFR APPROACHES. Controller automation would allow non-parallel IFR approach procedures to be conducted for greater lengths of time. This would increase the airport arrival rate by an average of eight arrivals-per-hour. Airports that would benefit from this technology include: BOS, BNA, BWI, CLE, CLT, CVG, DCA, EWR, FLL, HOU, IND, ISP, JFK, LAS, LGB, MEM, MIA, MKE, MSP, PBI, PDX, PHL, PIT, RDU, SAT, SDF, SFO, STL, SYR, TPA.

IMPROVED IFR LONGITUDINAL SEPARATION. Advances in wake vortex detection and monitoring devices would allow reduced longitudinal separation in the terminal environment. An average of three to five arrivals-per-hour per runway may be realized with a 2.5 nmi, or smaller, separation standard under IFR. Airports that have been approved to use new IFR longitudinal separation on final approach include: ATL, BOS, BNA, BWI, CLT, CVG, DCA, DEN, DFW, EWR, IAD, IAH, JFK, LAX, LGA, MCO, ORD, PHL, PIT, STL, [illegible].

RESULTS.

SYSTEM-WIDE. For the year 2005, the number of operations in the NAS is projected to increase by 7.8 million (34 percent), causing an increase of 3 million hours (143 percent) of delay. This translates into 8.7 billion dollars (193 percent increase) in delay costs. This projection is based on the 1991 TAF data, as well as airport improvements outlined in the NPIAS.

TABLE 3. ANNUAL DELAY AND COST OF DELAY FOR 1990 AND 2005.

	Year 1990	Year 2005
Number of Operations	22.9 million	30.7 million
Avg Delay/Aircraft	5.8 minutes	10.1 minutes
Total Delay	2.1 million hours	5.1 million hours
Cost of Delay	4.5 billion dollars	13.2 billion dollars

Ground delay, which is made up of pushback delay and taxi procedures from active runways, contributes about the same percentage of delay for the current, and future systems. This represents 77 percent of the delay produced from ground operations for the year 1990, and 78 percent for the year 2005. Weather related delays account for about 51 percent for the 1990 baseline, and about 35 percent for the future system. Future system delay, that is caused by adverse weather, consists of 60% ground delay and 40% airborne delay.

Annual savings, that could be realized from implementation of advanced technology designed to optimize runway usage through approach procedural changes, are displayed in table 4.

TABLE 4. SYSTEM-WIDE SAVINGS IN TECHNOLOGICAL ADVANCES

	Passenger Delay (hours)	Operational Delay (hours)	Passenger Cost (x $1,000)	Operational Cost (x $1,000)
Ind Par	135,000	155,000	310,000	300,000
Depend Par	31,000	62,000	92,000	156,000
Non-Par	345,000	267,000	687,000	538,000
Imp Long	75,000	119,000	224,000	223,000

Ind Par - Independent Parallel IFR Approaches
Depend Par - Dependent Parallel IFR Approaches
Non-Par - Non-Parallel IFR Approaches
Imp Long - Improved IFR Longitudinal Separation

AIRPORT LEVEL. Significant increases in delay for the year 2005, based solely on airfield improvements in the NAS, were shown at SFO, LAX, MIA, SNA, MSP, and FLL. The increase in delay is attributed to the projected increase in traffic at these airports with no plans to increase airport capacity. Table 5 displays the increase in annual operations and delay for each of these airports. Figure 1 shows the projected demand at these airports, plus additional airports with no planned airfield improvements. Figures 2 and 3 illustrate the difference in passenger and operational delay for these airports in the years 1990 and 2005. Passenger and operational delay costs are shown in figures 4 and 5.

TABLE 5. AIRPORTS WITH LARGEST DELAY INCREASES PROJECTED FOR 2005

Airport	Number of Operations	Passenger Delay (hours)	Operational Delay (hours)	Passenger Cost (x $1,000)	Operational Cost (x $1,000)
SFO	269,000	161,000	186,000	357,000	295,000
LAX	206,000	125,000	94,000	279,000	161,000
MIA	144,000	107,000	45,000	145,000	66,000
SNA	175,000	100,000	105,000	154,000	127,000
MSP	166,000	77,000	118,000	155,000	186,000
FLL	156,000	65,000	10,000	94,000	12,000

Measures of congestion at an airport are summarized in figure 6 and 7 by the percentage of operations delayed in excess of 15 minutes, and the average delay-per-aircraft.

The percentage of delay accumulated on the ground is depicted in figure 8. As shown, ground delay in years 1990 and 2005 makes up a majority of the delay for most of the airports that are modeled. The exception occurs at LGB, where most of the delay comes from airspace limitations. This is probably caused by the large amount of general aviation operations at LGB.

Delay attributed to weather is shown in figure 9, for all of the modeled airports, for the year 2005. As indicated by the bar chart, certain airports show greater weather-related delay. More than 50 percent of the total delay caused by adverse weather were reported at BDL, BOS, BWI, DCA, EWR, HOU, IND, ISP, JFK, LGA, MSP, and ORD. Volume was the cause of most of the delay at the remaining 46 modeled airports.

AIRSPACE CONGESTION. High traffic volume was observed at the following air route traffic control center (ARTCC) sectors: ZOB025, ZTL033, ZDC032, ZDC052, and ZID020 for the future system, with large sector entry delay occurring at ZMA020, ZMA061, ZAB093, ZDC032, and ZID020. Sectors which show the most activity for the year 2005 are displayed in figure 10. Please see appendix B for a complete list of ARTCCs.

CONCLUSIONS.

The analysis suggests that the majority of the future air traffic control (ATC) system delay is caused by airfield capacity limitations. The analysis revealed that over three-fourths of the delay recorded in the model comes from ground operations, and one-third of the future system delay is caused by adverse weather. This would indicate that the future ATC system would not adequately accommodate the projected increase in traffic volume at major airports, in the National Airspace System (NAS), without substantial delay. In addition to the airport improvements that are planned for the future ATC system, programs designed to increase airport capacity are needed to maintain acceptable levels of delay.

The scenarios that simulated different future technological advances, designed to increase airport capacity, resulted in varying amounts of delay savings. Although these scenarios were evaluated independent of each other, future studies could evaluate their contributions together, or in different stages of their development. Moreover, the ATC system baseline that was used in the study does not include all of the technological improvements that might exist for the future ATC system. Future studies of the National Airspace System Performance Analysis Capability (NASPAC), for evaluating system performance, will be based on an improved baseline that will reflect technologies designed to increase system capacity.

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The MITRE Corporation, Summary of Methodology Used to Derive NASPAC Weather Annualization Scenario Days and to Determine Annual Results, the MITRE Corporation, McLean, Va, 23 July 1991.

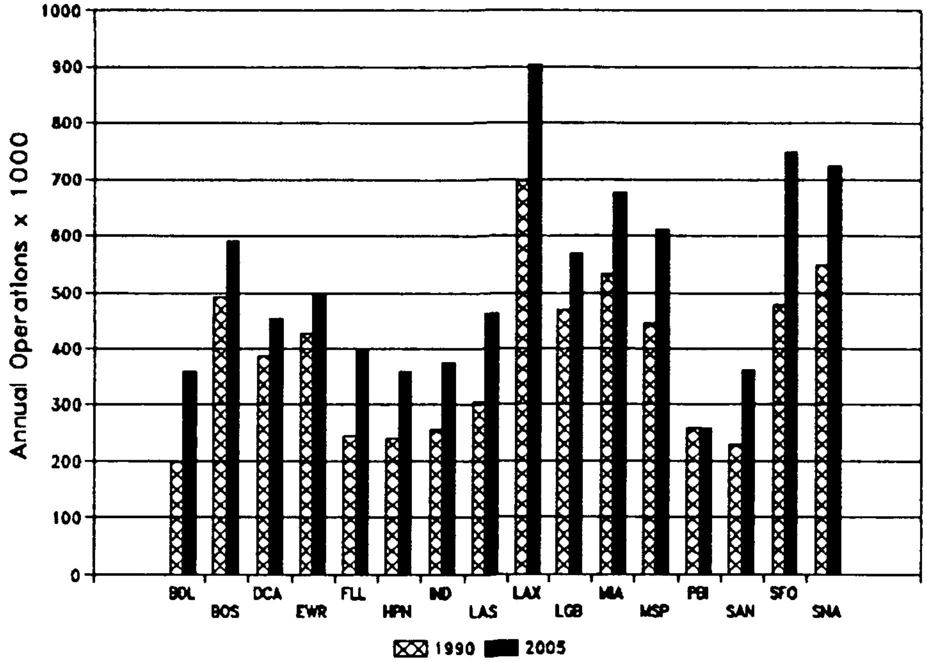

FIGURE 1. ANNUAL OPERATIONS

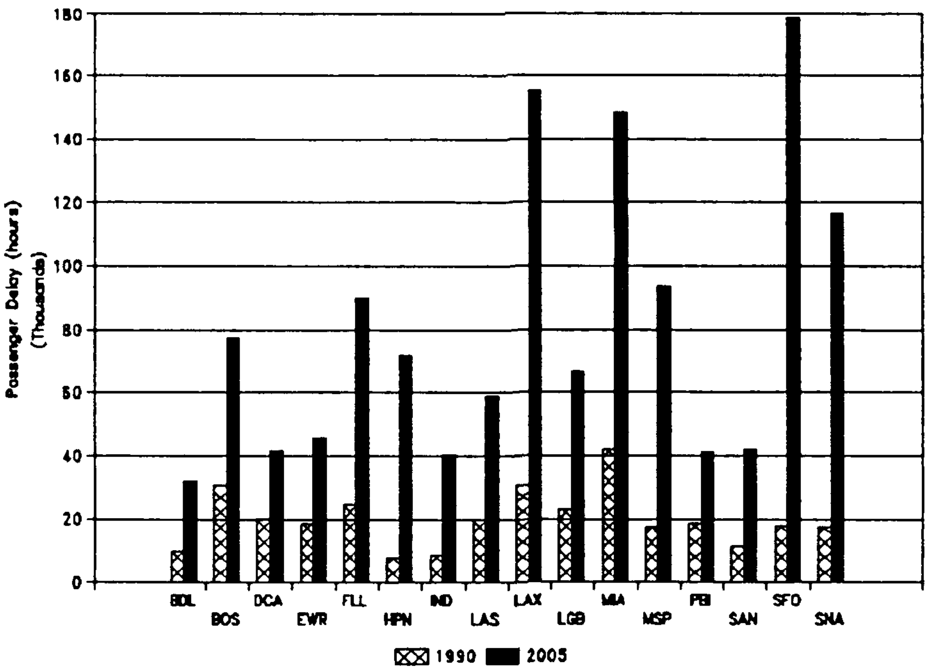

FIGURE 2. ANNUAL PASSENGER DELAY

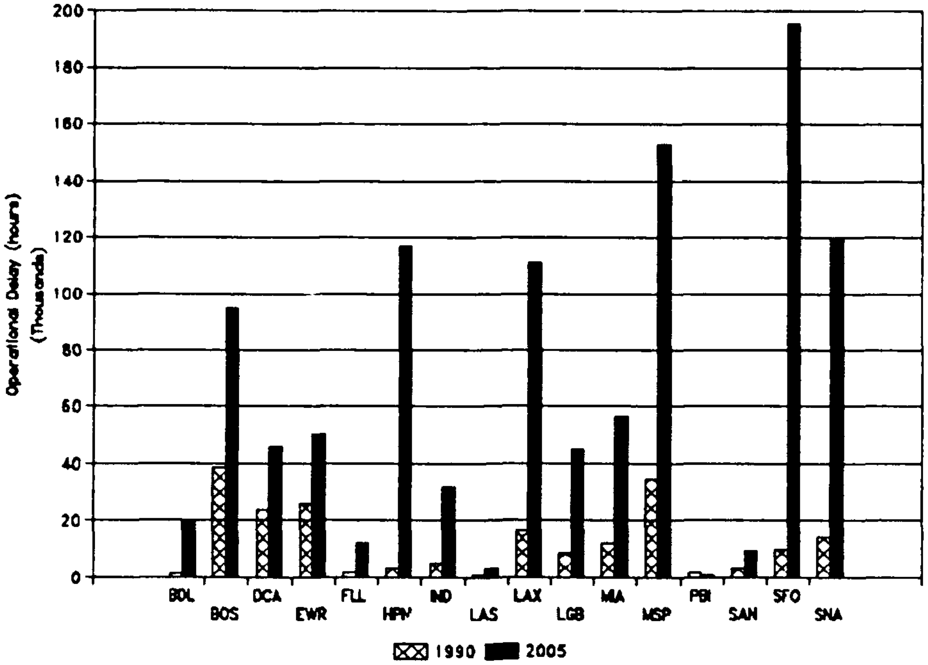

FIGURE 3. ANNUAL OPERATIONAL DELAY

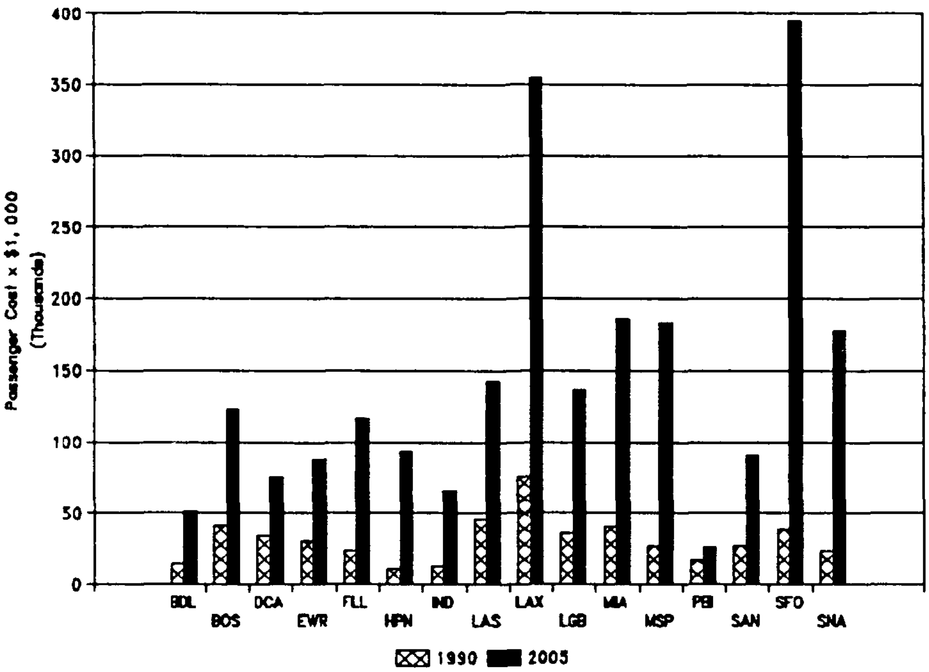

FIGURE 4. ANNUAL PASSENGER COST

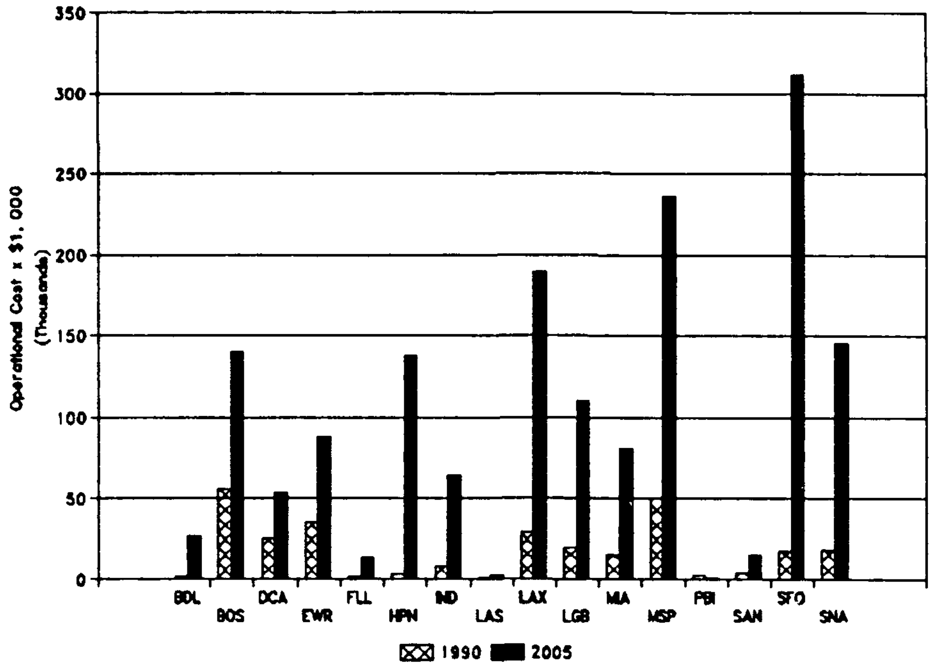

FIGURE 5. ANNUAL OPERATIONAL COST

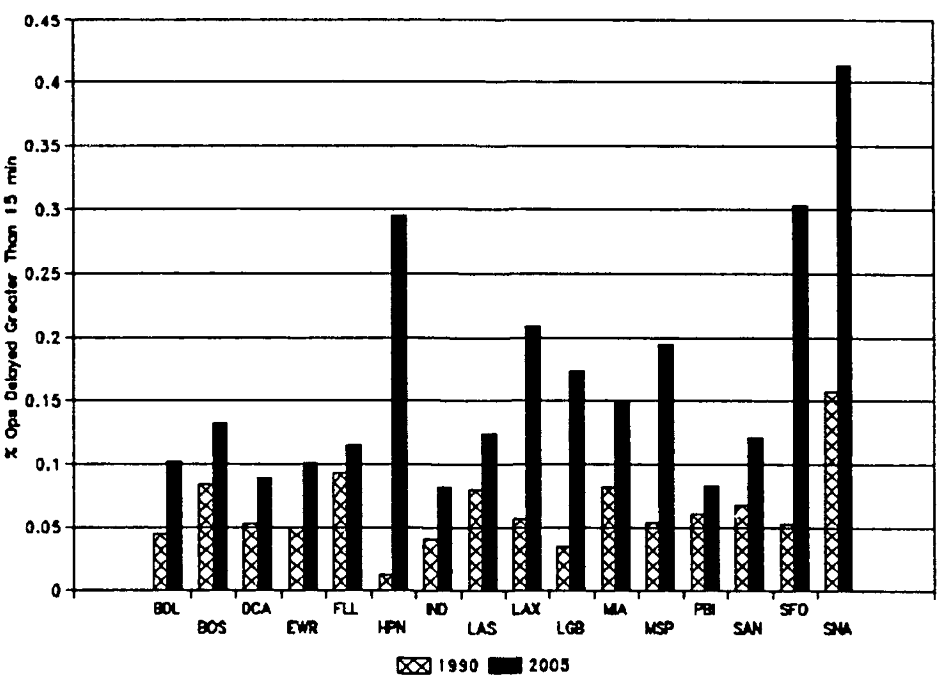

FIGURE 6. DELAY IN EXCESS OF 15 MINUTES

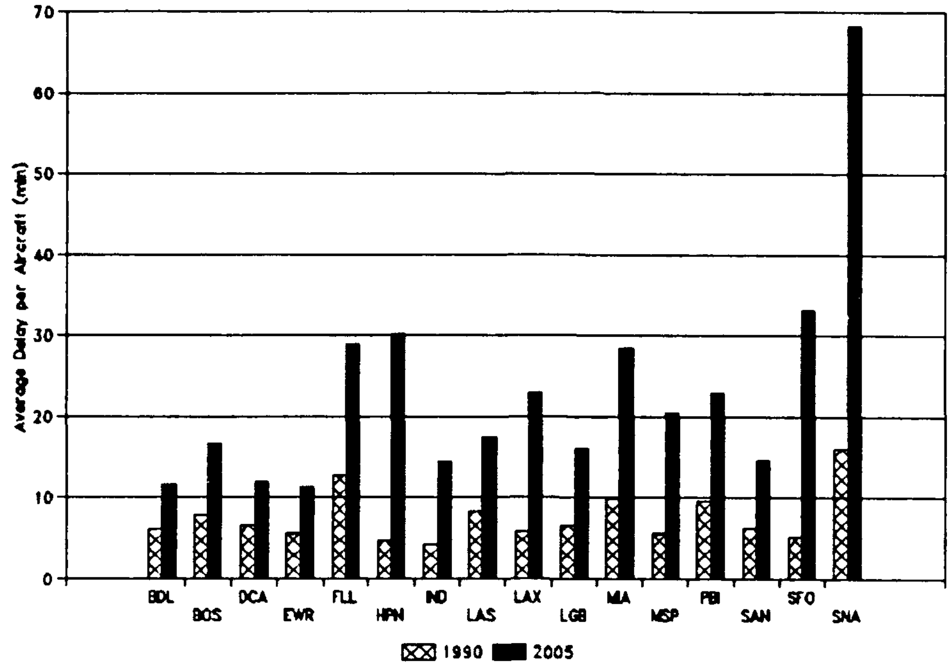

FIGURE 7. AVERAGE DELAY PER AIRCRAFT (1 OF 2)

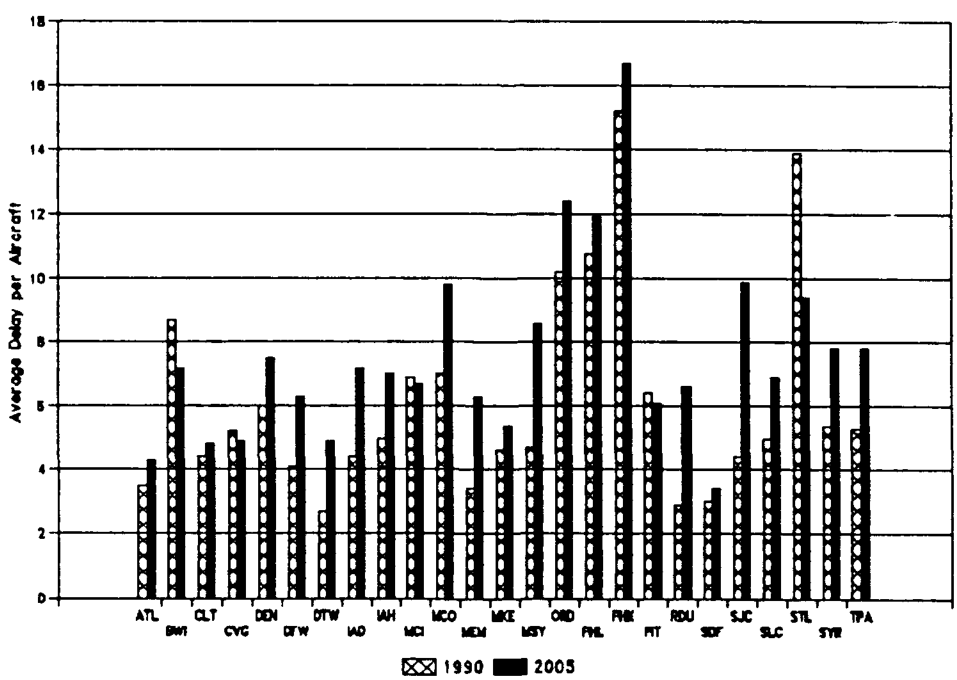

FIGURE 7. AVERAGE DELAY PER AIRCRAFT (2 OF 2)

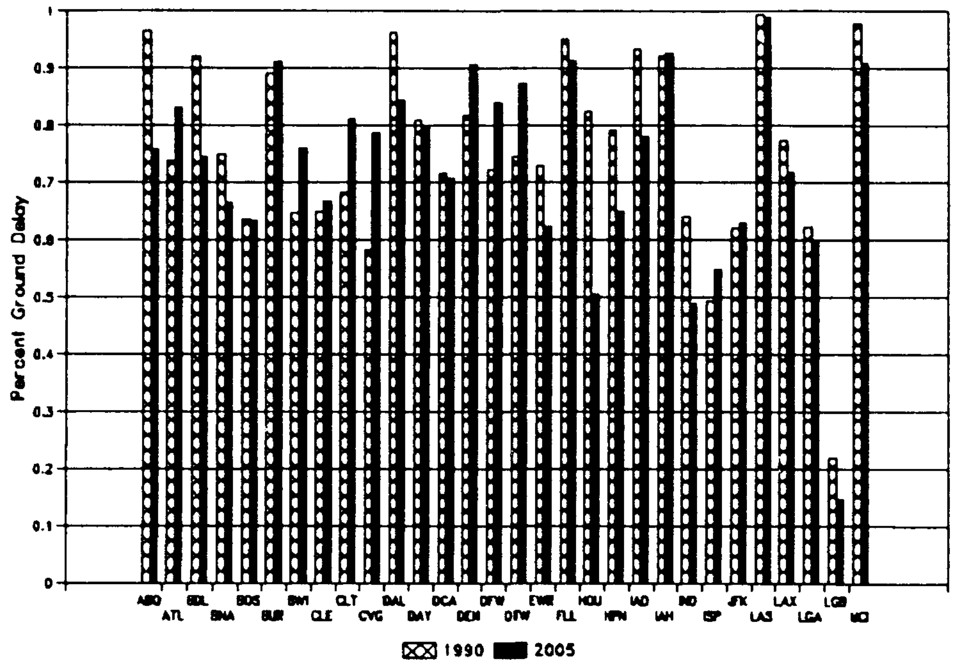

FIGURE 8. PERCENT GROUND DELAY (1 OF 2)

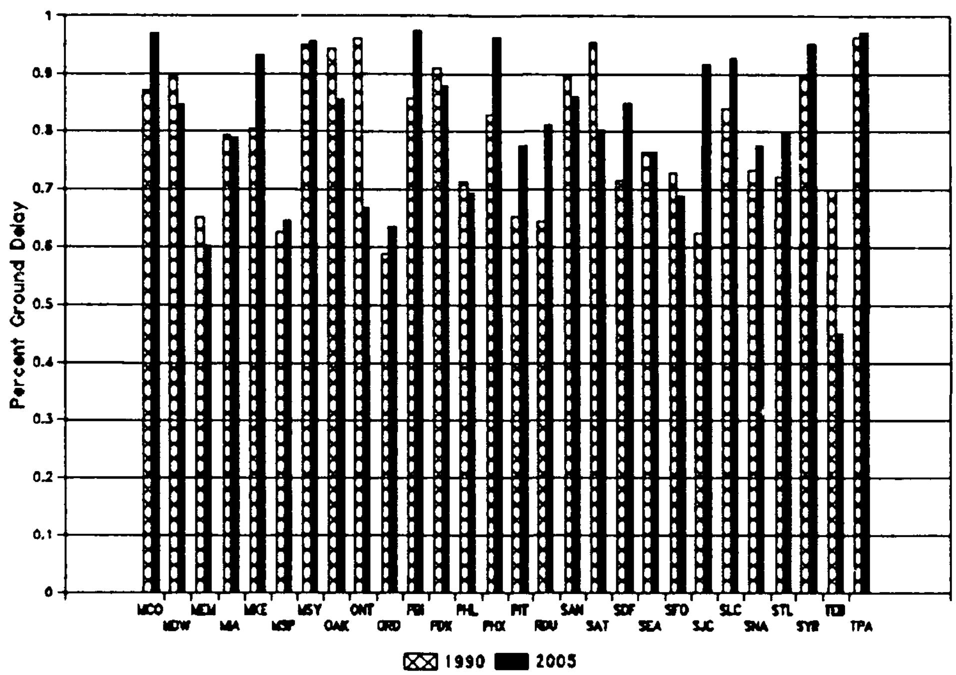

FIGURE 8. PERCENT GROUND DELAY (2 OF 2)

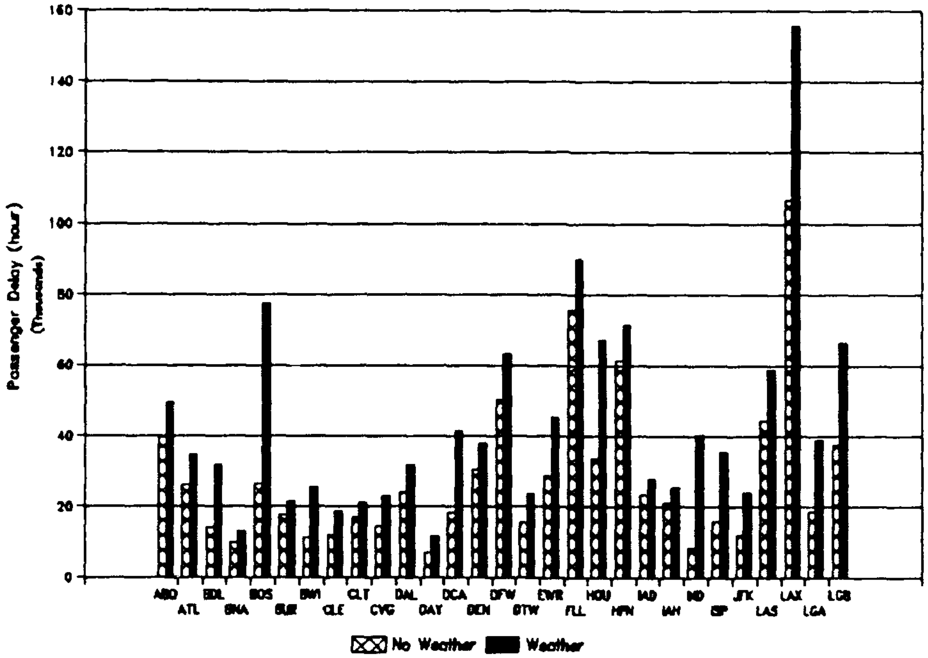

FIGURE 9. WEATHER RELATED DELAY (1 OF 2)

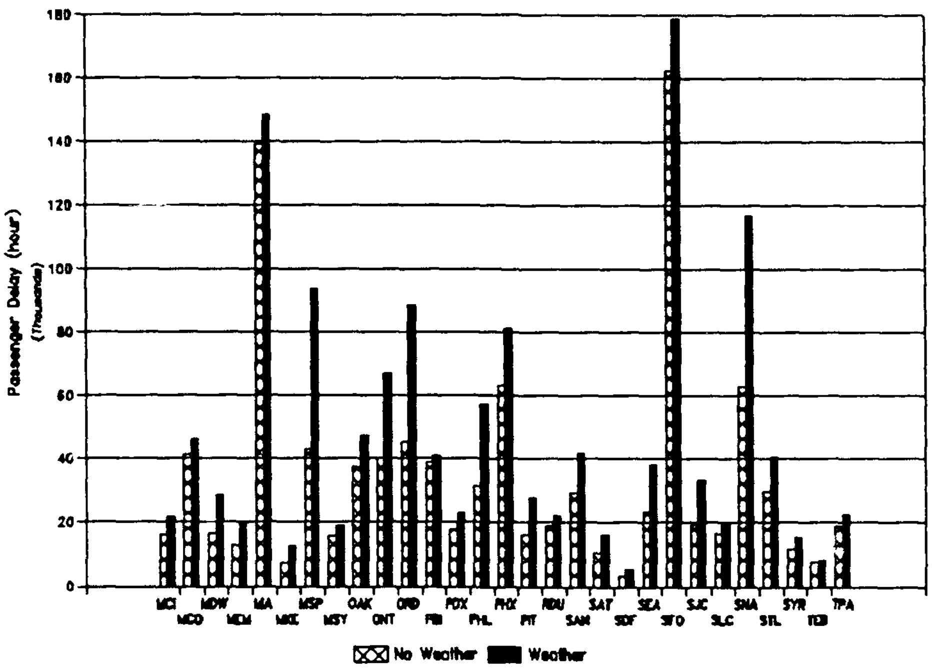

FIGURE 9. WEATHER RELATED DELAY (2 OF 2)

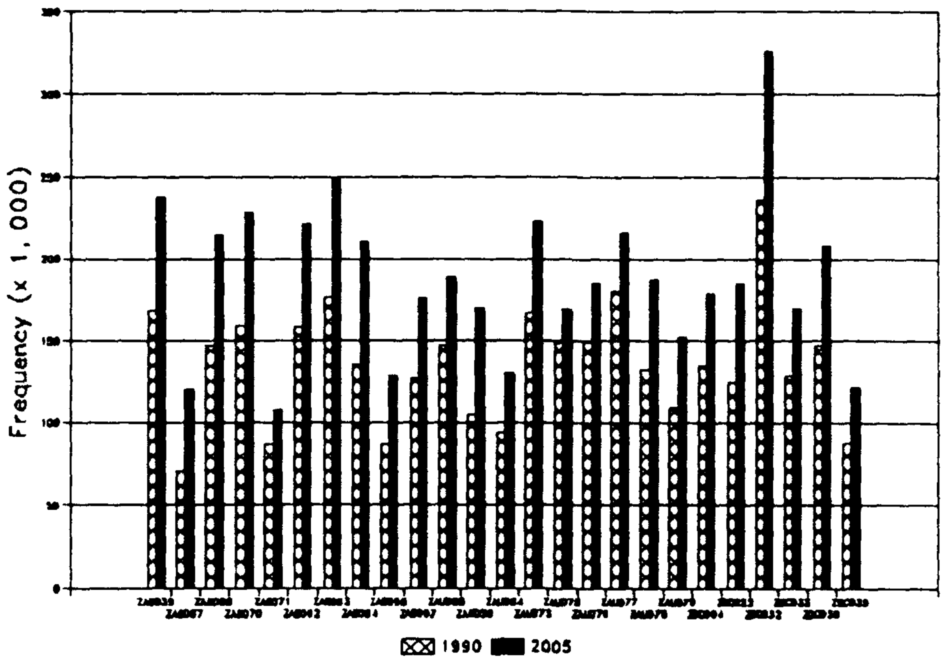

FIGURE 10. SECTOR THROUGHPUT (1 OF 2)

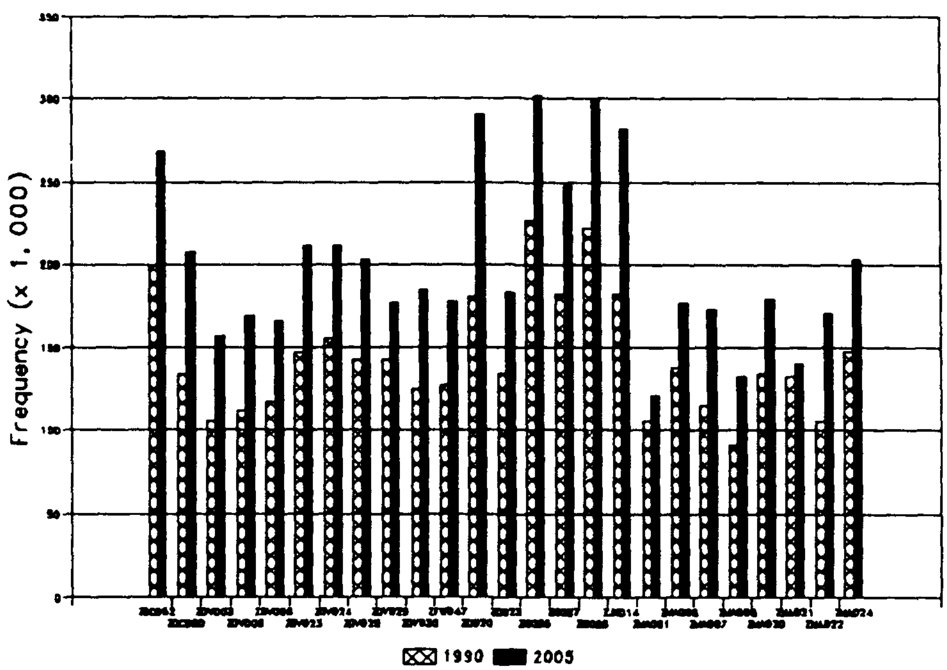

FIGURE 10. SECTOR THROUGHPUT (2 OF 2)

APPENDIX A

AIRPORTS MODELED BY NASPAC

Airport ID	Airport
ABQ	Albuquerque International Airport
ATL	Atlanta International Airport
BDL	Bradley International Airport
BNA	Nashville International Airport
BOS	Logan International Airport
BUR	Burbank-Glendale-Pasadena International Airport
BWI	Baltimore/Washington International Airport
CLE	Cleveland-Hopkins International Airport
CLT	Charlotte-Douglas International Airport
CVG	Cincinnati-Northern Kentucky International Airport
DAL	Dallas Love Field Airport
DAY	Dayton International Airport
DCA	Washington National Airport
DEN	Stapleton International Airport
DFW	Dallas/Fort Worth International Airport
DTW	Detroit Metropolitan Wayne County Airport
EWR	Newark International Airport
FLL	Fort Lauderdale/Hollywood International Airport
HOU	William P. Hobby Airport
HPN	West Chester County Airport
IAD	Washington Dulles International Airport
IAH	Houston Intercontinental Airport
IND	Indianapolis International Airport
ISP	Long Island Mac Arthur Airport
JFK	John F. Kennedy International Airport
LAS	McCarran International Airport
LAX	Los Angeles International Airport
LGB	Long Beach/Daugherty Field/Airport
MCI	Kansas City International Airport
MCO	Orlando International Airport
MDW	Chicago Midway Airport
MEM	Memphis International Airport
MIA	Miami International Airport
MKE	General Mitchell International Airport
MSP	Minneapolis-St. Paul International Airport
MSY	New Orleans International/Moisant Field Airport
OAK	Metropolitan Oakland International Airport
ONT	Ontario International Airport
ORD	Chicago O'Hare International Airport
PBI	Palm Beach International Airport
PDX	Portland International Airport
PHL	Philadelphia International Airport
PHX	Phoenix Sky Harbor International Airport
PIT	Pittsburgh International Airport
RDU	Raleigh-Durham International Airport
SAN	San Diego International-Lindbergh Field Airport

AIRPORTS MODELED BY NASPAC (cont.)

Airport ID	Airport
SAT	San Antonio International Airport
SDF	Standiford Field Airport
SEA	Seattle-Tacoma International Airport
SFO	San Francisco International Airport
SJC	San Jose International Airport
SLC	Salt Lake City International Airport
SNA	John Wayne Airport-Orange County Airport
STL	Lambert-St. Louis International Airport
SYR	Syracuse Hancock International Airport
TEB	Teterboro Airport
TPA	Tampa International Airport

APPENDIX B

AIR ROUTE TRAFFIC CONTROL CENTERS (ARTCCs)

IDENTIFIER	ARTCC	LOCATION
ZAB	Albuquerque	Albuquerque, NM
ZAU	Chicago	Chicago, IL
ZBW	Boston	Nashua, NH
ZDC	Washington	Washington, DC
ZDV	Denver	Denver, CO
ZFW	Fort Worth	Fort Worth, TX
ZHU	Houston	Houston, TX
ZID	Indianapolis	Indianapolis, IN
ZJX	Jacksonville	Jacksonville, FL
ZKC	Kansas City	Kansas City, MO
ZLA	Los Angeles	Los Angeles, CA
ZLC	Salt Lake City	Salt Lake City, UT
ZMA	Miami	Miami, FL
ZME	Memphis	Memphis, TN
ZMP	Minneapolis	Minneapolis, MN
ZNY	New York	New York, NY
ZOA	Oakland	Oakland, CA
ZOB	Cleveland	Cleveland, OH
ZSE	Seattle	Seattle, WA
ZTL	Atlanta	Atlanta, GA

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